Book of theses

**Use of network approach in the improvement of operation
efficiency on the field of quality development**

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1   Introduction

Author as a manager of an information technology and process improvement consulting company realized the problem that huge effort has to be conducted in order to make new systems and processes accepted by organization. Supporting this work, he was searching for new techniques. Due to this research he became interested in sociometry and network science. Based on new information he created a network oriented change management method and IT application. The successful use of these techniques inspired him to mine deeper in network science and to assess the state of the art results to develop new network oriented methodologies on the field of quality management, focusing on process improvement opportunities.

There are many connections between network science and quality management. The Analytic Network Process (ANP) is a method for multi-criteria decision, where there are mutual connections between decision criteria and alternatives. ANP was applied many times to compare decision alternatives or to identify the key points of quality assurance activities. The combination of ANP and Quality Function Deployment (QFD) can help to prioritize technology parameters of some products.

Modelling processes by networks is a widely spread approach. There are many types of networks for process modelling with different interpretations of vertices and edges. For instances the Business Process Modelling Notation (BPMN) is a standardized way for modelling repetitive business processes, where vertices represent activities and events, edges represent the logical and flow connections among them. The Critical Path Method (CPM) is used for identify the chain of activities with no spare time in a project. In CPM network vertices represent events, edges represent activities. The artificial neural networks are used to find the optimal set of parameters of a process by the assessment of cause-effect connections between input and output parameters.

Although beside the techniques mentioned above there are many more examples of using network approach for quality management, no works have been conducted for assessing the opportunity of using network science results on the field of quality management. So the Author developed a new way of specifying and grouping networks can be interpreted in quality management. Than he defined the achievement to develop new network oriented techniques for process improvement.

2   Applied methods

Methods applied during the research come on the one hand side from network science and on the other hand side from process modelling and assessment.

Author identified the attributes of processes can be described and calculated by network attributes. He defined these network attributes and the way of calculation and descriptions. The connection among process and network attributes are explained from the simplest to the most complex structure.

The new methodology is tested by identifying and calculating Lean wastes. The special process networks are modelled and analyzed by Pajek and NodeXL software.

3   Results

Author created a new way of grouping networks that can be interpreted in quality management. He defined the flow, the attribute and the preference types of edges, and the event, the resource and the competence types of vertices. A network can be identified and described based on these types of vertices and edges. Author gives examples for all combinations of different types of vertices and edges.

Author developed the Network-based Process Indicator Model (NPIM), which structures process performance indicators can be calculated by network attributes of network models of processes. [Figure 1]

Activity balancing

$$\sigma = \frac{K_{ki_{WT}}}{K_{be_{WT}}} = \frac{\sum_{j=1}^{m} WT_{ki_j} E_{ki_j}}{\sum_{l=1}^{z} WT_{be_l} E_{be_l}}$$

$$\sigma = \frac{K_{ki_N}}{K_{be_N}} = \frac{\sum_{j=1}^{m} N_{ki_j} E_{ki_j}}{\sum_{l=1}^{z} N_{be_l} E_{be_l}}$$

Unit lead time

$$TLT_{\varepsilon x} = \sum_{i=1}^{v} CT_{i_x} + \frac{\sum_{j=1}^{v} WT_{be_{j_x}} E_{be_{j_x}} + \sum_{j=1}^{v} WT_{ki_{j_x}} E_{ki_{j_x}}}{2}$$

Activity utilization

$$U = \frac{1}{\sigma} = \frac{\sum_{l=1}^{z} N_{be_l} E_{be_l}}{\sum_{j=1}^{m} N_{ki_j} E_{ki_j}}$$

Process fault rate

$$F = \frac{E^-}{E}$$

No of units

$$\beta = \sum_{i=1}^{n} \left(E_{be_i} - E_{ki_i} + N_{be_i} \right)$$

Process yield

$$\pi = \frac{\sum_{i=1}^{n} (1 - \delta) E_i}{E}$$

No of faults / No of fault opportunities
δ

Waiting time
WT

Cycle time
CT
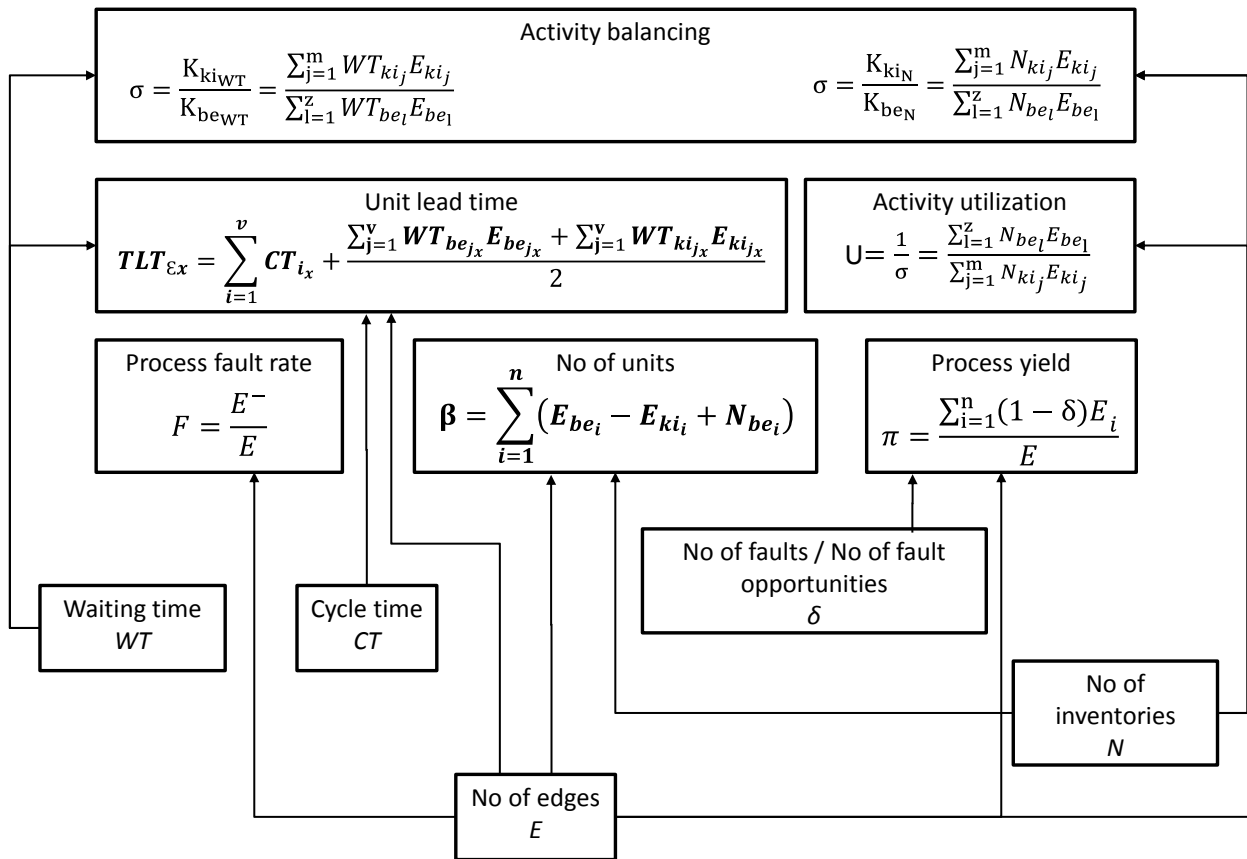
No of inventories
N

No of edges
E

Figure 1: Network-based Process Indicator Model (NPIM).

Author used NPIM to identify Lean wastes. He defined the connection among wastes and network attributes. [Figure 2]
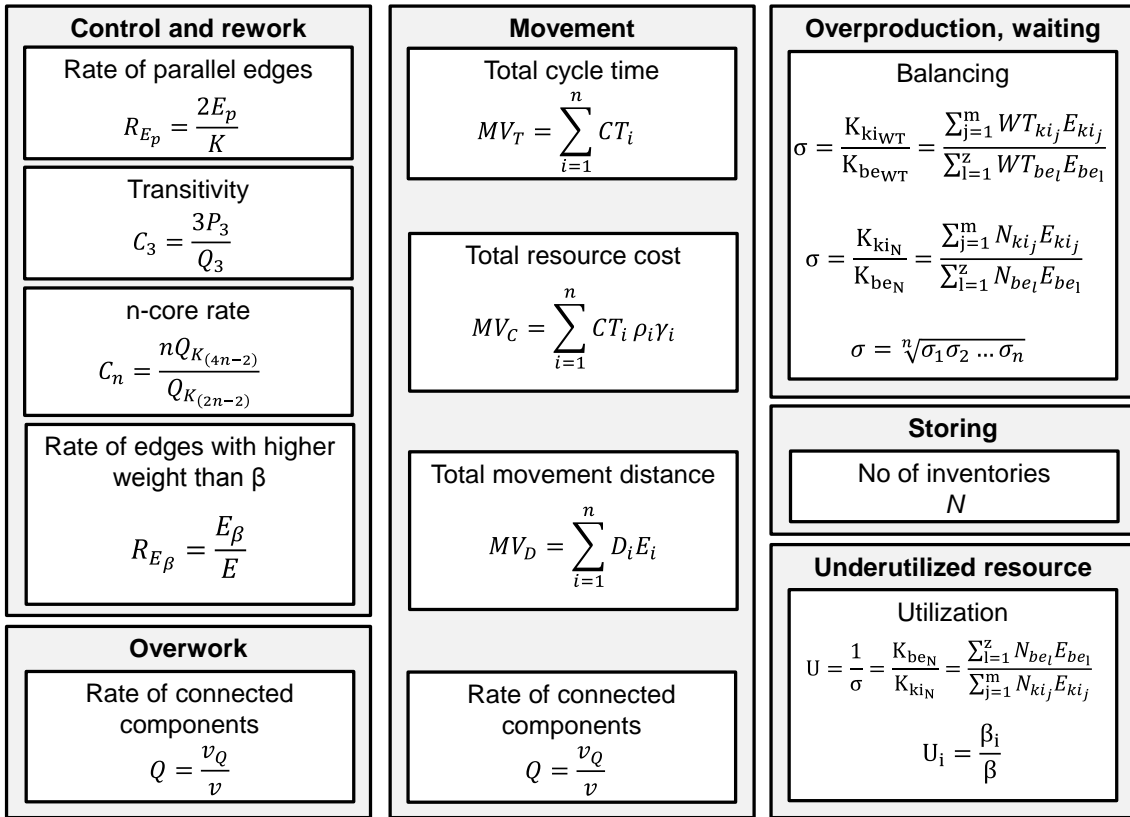
Control and rework

Rate of parallel edges

$$R_{E_p} = \frac{2E_p}{K}$$

Transitivity

$$C_3 = \frac{3P_3}{Q_3}$$

n-core rate

$$C_n = \frac{nQ_{K_{(4n-2)}}}{Q_{K_{(2n-2)}}}$$

Rate of edges with higher weight than β

$$R_{E_\beta} = \frac{E_\beta}{E}$$

Overwork

Rate of connected components

$$Q = \frac{v_Q}{v}$$

Movement

Total cycle time

$$MV_T = \sum_{i=1}^{n} CT_i$$

Total resource cost

$$MV_C = \sum_{i=1}^{n} CT_i \rho_i \gamma_i$$

Total movement distance

$$MV_D = \sum_{i=1}^{n} D_i E_i$$

Rate of connected components

$$Q = \frac{v_Q}{v}$$

Overproduction, waiting

Balancing

$$\sigma = \frac{K_{ki_{WT}}}{K_{be_{WT}}} = \frac{\sum_{j=1}^{m} WT_{ki_j} E_{ki_j}}{\sum_{l=1}^{z} WT_{be_l} E_{be_l}}$$

$$\sigma = \frac{K_{ki_N}}{K_{be_N}} = \frac{\sum_{j=1}^{m} N_{ki_j} E_{ki_j}}{\sum_{l=1}^{z} N_{be_l} E_{be_l}}$$

$$\sigma = \sqrt[n]{\sigma_1 \sigma_2 \dots \sigma_n}$$

Storing

No of inventories

$$N$$

Underutilized resource

Utilization

$$U = \frac{1}{\sigma} = \frac{K_{be_N}}{K_{ki_N}} = \frac{\sum_{l=1}^{z} N_{be_l} E_{be_l}}{\sum_{j=1}^{m} N_{ki_j} E_{ki_j}}$$

$$U_i = \frac{\beta_i}{\beta}$$

Figure 2: The network indicator structure of Lean wastes.

Author proved that process is changing during its lifecycle and that the assessment of this phenomena can be conducted by network oriented process indicators. He defined a network model for describing process change and created special process networks to analyze this.

Author presents a methodology for the identification and assessment of processes, which was developed to select processes that can be and have to be improved, and to understand the actual running and characteristics of process. With these techniques he specified network oriented graphical and analytical methods for process analyzes.

He used network approach to assess quality and process related risks too. As a result he developed new methods for calculating knowledge value in an organization and for analyzing risks management systems (NTS network).

4   Theses

Thesis 1: Author created a new way of grouping of networks that can be interpreted in quality management. He gives examples for all combinations of different types of vertices and edges.

a) Author defined the flow, the attribute and the preference types of edges with the description of direction, weight, positive and negative signs, loop, serial and parallel connections and cohesive subgroups. He also defined the event, the resource and the competence types of vertices.

Relevant publications: [1], [5].
Relevant conference speaking activities: [1]

b) Author gives practical examples for all combinations of different types of vertices and edges from the field of quality management.
Relevant publications: [1], [5].
Relevant conference speaking activities: [1]

Thesis 2: Author developed a new method of network oriented process assessment.

a) Author defined local and global network attributes that are able to analyze performance of activities and to qualify the whole process. He defined the Network-based Process Indicator Model (NPIM) for describing connection among indicators. He defined the network oriented interpretation of process quality.
Relevant publications: [5].
Relevant conference speaking activities: [3]

b) Author tested the new approach with the identification of connection between NPIM and Lean wastes. He specified network indicators that are able to calculate Lean wastes.
Relevant publications: [5].
Relevant conference speaking activities: [2]

Thesis 3: Author developed a new network model for the description and analyzes of the changes of processes in their lifecycles.

a) Author defined the phases of processes in their lifecycles. He identified the possible reasons of changes from a phase to another one, and he identified the effect of changes to the topology of network model.
Relevant publications: [1]
Relevant conference speaking activities: [5]

b) Author specified the phases with the most important network attributes.
Relevant publications: [1]
Relevant conference speaking activities: [5]

Thesis 4: Author developed a new methodology for the practical application of network oriented process improvement.

a) Author defined a method for the prioritization and assessment of processes from the potential for implementation perspective. He described the alternatives of data collection for creating network models of processes. He developed the graphical and analytical techniques of network oriented process diagnostics.

Relevant publications: [6]
Relevant conference speaking activities: [2]

b) Author identified the application opportunities of network approach in prediction, monitoring and analyzes of process operation problems. He developed the NTS network for the validation of risk management activities. He developed a new method for the calculation of knowledge items and the risk for their disappearing from the organization.
Relevant publications: [7], [1]
Relevant conference speaking activities: [7]

5 Alkalmazási lehetőség

Results can be applied for process improvement, focusing on the prevention and handling of negative changes and the identification and calculation of Lean wastes. According to Author's experience the more complex a process is, the more reasonable the use of network approach is.

The new network oriented techniques can be applied for validating risk management systems (NTS network), and for supporting knowledge management with the identification of key competencies.

6 Publications

[1] Csiszér, T. (2010): A hálózatelemzési eszköztár alkalmazásának lehetőségei a működésfejlesztésben, "TANULÁS - TUDÁS - GAZDASÁGI SIKEREK", avagy a tudásmenedzsment szerepe a gazdaság eredményességében konferencia kiadványa, Széchenyi István Egyetem, Győr.
[2] Csiszér, T (2010): Eseménykapcsolatok vizsgálata hálózatelemzési módszerrel, Hálózatkutatás, interdiszciplináris megközelítések, ELTE Eötvös Kiadó, Budapest.
[3] Csiszér, T., Solti, Á. (2010): Folyamat alapú informatikai rendszerfejlesztés és bevezetés, IME IX. évfolyam 4. szám, Larix Kiadó Kft., Budapest.
[4] Csiszér, T. (2011): Kockázati események közötti összefüggések vizsgálata hálózatelemzéssel, Magyar Minőség, Minőség hét kiadvány, Magyar Minőség Társaság, Budapest.
[5] Csiszér, T. (2011): A hálózatkutatás alkalmazási lehetőségének összefoglaló vizsgálata a folyamatalapú minőségfejlesztésben, Minőség és Megbízhatóság 5. kötet, EOQ MNB, Budapest.
[6] Csiszér, T. (2012): A tudásérték meghatározása minőségügyi szempontból, hálózatelemzési módszerekkel, Vezetéstudomány 43. kötet, Corvinus School of Management, Budapest.
[7] Csiszér, T (2013): Assessment of quality-related risks by the use of complex networks, Acta Silvatica et Lignaria Hungarica, 9. kötet, Magyar Tudományos Akadémia Erdészeti Bizottsága, Sopron.

7 Conference speaking activities

[1] Brassó-Sopron Doktorandusz Konferencia, 2011 - A hálózatkutatás alkalmazási lehetőségének összefoglaló vizsgálata a folyamatalapú minőségfejlesztésben

[2] IIR Folyamatmenedzsment szeminárium, 2012 - A folyamatfejlesztés projektszerű megvalósításának gyakorlati kérdései

[3] Nyugat-magyarországi Egyetem, Doktorandusz konferencia, 2012 - A hálózatok szerepe a minőségügyi fejlesztésekben

[4] Nyugat-magyarországi Egyetem, Doktoranduszi konferencia, 2011 - A hálózatszemlélet alkalmazása a működéshatékonyság növelésében a minőségügyi fejlesztések területén

[5] Nyugat-magyarországi Egyetem, Hálózatkutatás konferencia, 2010 – Eseményhálózatok vizsgálata

[6] Nyugat-magyarországi Egyetem, Doktoranduszi konferencia, 2010 - A hálózatelmélet alkalmazása a minőségfejlesztésben

[7] Personal Hungary Szakkiállítás, 2010 - Hálózatalapú tudásmenedzsment rendszer

[8] "TANULÁS - TUDÁS - GAZDASÁGI SIKEREK", avagy a tudásmenedzsment szerepe a gazdaság eredményességében konferencia, 2010 - A hálózatelemzési eszköztár alkalmazásának lehetőségei a működésfejlesztésben

[9] OHKK konferencia, 2009 – A hálózatanalitika szerepe a működésfejlesztésben